DEPARTMENT OF WATER AFFAIRS AND FORESTRY
Recreational Water Use Manual
Guideline

Subject: Methodology for Determining Carrying Capacity.

Purposes: To assist water resource planners and managers to determine the carrying capacity of a water resource in respect of water-based recreational visitor use and related infrastructure.

Authority: Operational Policy for Recreational Water Use, August 2004

Approval: Director: Water Abstraction and Instream Use, October 2006.

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1. INTRODUCTION

Sustainability, whether it is ecological, social or economic, is regarded as an objective of most human activities. The need to balance environmental concerns through utilisation on appropriate levels has resulted as a result of awareness created by publications such as Caring for the Earth (IUCN/UNEP/WWF; 1991), the Brundtland Report (1987) and the adoption of Agenda 21 at the Earth Summit in 1992.

For recreational water utilisation, in particular, to be sustainable, it is imperative that the activity should continue to provide benefits indefinitely. According to Munro (1995): “this means that there must be nothing inherent in the process or activity concerned, or in the circumstances in which it takes place, that would limit the time it can endure.” Additionally, it is important that the activity remains worthwhile, meeting both social and economic objectives.

Sustainable utilisation of water resources is thus the development of a complex of activities that can be expected to improve the human and environmental condition in such a manner that the improvement can be maintained. Applying the concept of sustainable utilisation requires attention being focused on development within the carrying capacity of the supporting ecosystems, resulting biophysical, socio-cultural and economic sustainability.

Carrying capacity can be defined as the capacity of a system to support healthy organisms while maintaining its productivity, adaptability and capacity of renewal, effectively representing a threshold level of human activity which if exceeded will result in the deterioration of the resource base.

The carrying capacity of a water resource represents the maximum level of visitor use and related infrastructure that the water resource and surrounding area can accommodate, without diminishing user satisfaction or adverse impacts upon the local or host community, the economy and culture of the area.

Four basic components form part of the carrying capacity of a water resource, namely:

- Biophysical;
- Socio-cultural;
- Psychological; and
- Managerial.

It is not difficult to theoretically understand the concept of carrying capacity, however it is difficult to quantify since the capacity will vary depending on the water use or combination thereof, as well as the environment.

The carrying capacity will vary depending upon place, season and time, user behaviour, facility and infrastructure design, patterns and levels of management and the changing dynamics of the environment. When determining carrying capacity for a specific water resource it is essential to have a clear knowledge and understanding of the impacts that activities have on water resources, and that the relationships between the environmental resources, local community expectations and visitor expectations are managed in a harmonious and balanced way.

2. BASIC COMPONENTS OF CARRYING CAPACITY

The biophysical component relates primarily to the natural resources, and recognises that no biophysical system can withstand unlimited utilisation. Assessing the biophysical carrying capacity of a resource is often used as a management tool in protected area management and relies on the identification of thresholds beyond which irreversible and detrimental changes in the biophysical environment could occur, such as habitat degradation or loss and elimination of species or populations.

The socio-cultural component of carrying capacity recognises that detrimental impacts on the local or host community will occur if the water use or users exceed a certain level. However, since it is very difficult to assess and evaluate socio-cultural carrying capacity it is essential that experts such as anthropologists, and archaeologists be included in the assessment and evaluation phase. Perceptions regarding acceptable impacts and effects will vary both between the host community and visitors, as well as within each group.

The psychological component of carrying capacity refers to the maximum number of users for whom a water resource area is able to provide a quality experience at any one time. The psychological capacity varies according to the area, type of activity and resource, and the specific characteristics of each user or group of users. Due to the difficulty of establishing evaluative standards the psychological carrying capacity must be measured in terms of the area's objective and the limits of acceptable change.

The managerial component of carrying capacity refers to the maximum level of use that can be managed adequately in a given area, linked to the type of physical facilities and staff to manage users.

3. MEASURING CARRYING CAPACITY

In order to define carrying capacity of a water resource it is important that information is obtained regarding the resource itself, infrastructure and objectives for the area. The carrying capacity for each water resource will thus be specific based on environmental, social and economic objectives.

Key parameters that can be used to determine carrying capacity include:

- Type of activity;
- Season;
- Time of day;
- Existing facilities; and
- Satisfaction level of users

Indicator parameters can be used to ascertain success regarding carrying capacity levels, and can include:

- Species;
- Water quality;
- Visible damage; and
- Satisfaction levels of communities and users

Two types of descriptive data can be used to measure and describe carrying capacity, namely:

- Management parameters – any action that can directly manipulate the source of the impact such as limiting the number of visitors or users, type of use and duration of use; and
- Impact parameters – measurable description of impact of impacts directly as result of use pattern and management actions such as percentage loss of ground cover, frequency of encounters with other users, changes in quality, species diversity and density.

Based on the measurement and description it is essential that the results be evaluated, in order to produce a set of objectives or standards specifying the type of experience to be provided in terms of appropriate impact parameters, as well as the limits of change acceptable to management.

4. LIMITS OF ACCEPTABLE CHANGE

The difficulties associated with setting and measuring carrying capacity can be overcome by shifting the focus from an appropriate use level to the desired condition, thereby clarifying the relationship between use and impact. The question shifts thus from “How much use is too much?” to “What conditions are desired here?”.

To set limits of acceptable change it is important to establish measurable limits to human-induced changes in the natural and social environments, and to identify appropriate management strategies to maintain or restore desired conditions.

The use of Carrying Capacity Assessments (CCA) and the setting of Limits of Acceptable Change (LAC) is not aimed at ecological management, but rather at more effective management regarding the impacts of activities on resources. Various understandings of the terms exist, of which Cifuentes (1992) and Ceballos-Lascurain (1996) provide some practical guidelines regarding the use of these as manage tools.

5. THE PROCESS

The process of estimating carrying capacity consists of six steps, namely:

- Analysis of recreation and water resource management policies;
- Analysis of objectives of the water resource;
- Analysis of current recreational water use;
- Definition, strengthening or modification of policies regarding recreational water use management;
- Identification of factors influencing recreational water use; and
- Determination of the recreational water use carrying capacity.

Each of these steps is important and constitutes an interrelated and sequential whole.

Step 1: Analysis of Recreation and Water Resource Management Policies

Policies regarding recreational development and water resource management address the needs and expectations of each separately, and are often contradictory and non-complementary, which hinders sound and sustainable development.

It is imperative that before setting levels of usage through carrying capacity assessment the gaps, potential and contradictions between recreation and water resource management be identified and contextualised.

Step 2: Analysis of Water Resource Objectives

It is essential to determine whether the recreational water use activity is suitable and appropriate with the water resource and the objectives set for the water resource. Questions that must be answered include:

- Are the current activities acceptable, compatible and appropriate?
- Are the current levels and patterns of use appropriate?

Step 3: Analysis of Current Recreational Water Use

An analysis of the current utilisation patterns must be undertaken based on aspects such as the objectives of a water resource contained in the management plan, which should include the management zones.

Questions that must be asked during this analysis include:

- Are the management objectives being met?
- Is the zonation plan adequate for the accomplishment of the recreational water resource objectives?

- Are the zones appropriate for the utilisation and have they been identified correctly?
- Do conflicts exist, and if so how can they be eliminated or attenuated?
- Are changes to the zonation plan and management plan necessary to address both current and projected circumstances?

Step 4: Definition, Strengthening or Modification of Policies Regarding Recreational Water Use Management

Steps 1 – 3 allow for a synthesis of the potentialities and conflicts, both present and future, that have been identified in respect to the management of water resources for recreational purposes. This synthesis will contribute to defining and proposing new objectives, policies, strategies and operational guidelines, as well as strengthen or modify existing measures.

Step 5: Identification of Factors Influencing Recreational Water Use

It is critically important that detailed knowledge of the specific characteristics of each recreational water resource be available. Each resource will have different biophysical and socio-cultural characteristics, with natural and cultural attractions. An understanding of the quantitative and qualitative aspects is essential, as is an assessment of the resource's fragility and vulnerability.

Sustainability will only be achievable if a harmonious balance can be attained between the biophysical, ecological, social and management factors that modify the conditions and supply of water resources.

Step 6: Determination of Recreational Water Use Carrying Capacity

Three levels of recreational water use carrying capacity can be established:

- Physical Carrying Capacity (PCC);
- Real Carrying Capacity (RCC); and
- Effective or Permissible Carrying Capacity (ECC).

Each level constitutes a corrected capacity level of the preceding level.

The PCC is always greater than the RCC, and the RCC is greater than the ECC, thus:

PCC > RCC and RCC ≥ ECC

Physical Carrying Capacity (PCC)

Definition: The maximum number of users that can physically fit into or onto a defined water resource, over a particular time.

Formula: PCC = A x U/a x Rf

Where:

A = available area for public use
U/a = area required per user
Rf = rotation factor (number of visits/day)

Assumptions: To measure the PCC, the following assumptions must be clarified:

- U/a - the area required by recreational water users to undertake activities;
- A - that the available area (A) is determined by the particular conditions of the water resources, and by limitations imposed due to fragility or as a result of the need for safety precautions; and
- Rf – the rotation factor is the number of permissible daily visits to a water resource, determined by:

Rf = Open period / [Average time of utilisation/visit]

Real Carrying Capacity (RCC)

Definition: The maximum permissible number of users to the water resource, once the corrective factors (Cf) derived from the particular characteristics of the site have been applied to the PCC.

Formula: RCC = PCC – Cf1 – Cf2 – Cfn

Where:

Cf = a corrective factor expressed as a percentage

RCC = PCC x (100 – Cf1)% x (100 – Cf2)% x (100 – Cfn)%

Assumptions: To measure the RCC, the following assumptions must be clarified:

- Cf - the corrective factors are obtained by considering the biophysical, environmental, ecological, social and management variables;
- That a group of corrective factors is not necessarily the same for each site in a water resource;
- Corrective factors are closely linked to the specific conditions and characteristics of each site or activity;
- That the carrying capacity of a water resource must be measured site by site; and
- Corrective factors are expressed in percentage terms using the following formula:

Cf = [M1 / Mt] x 100

Where:

Cf = corrective factor
M1 = limiting magnitude of variable
Mt = total magnitude of variable

Corrective factors:

- E.g. Pongola – Excessive sunshine; wind; water quality; temporary closing; mud; and wildlife (crocodiles, birds, hippopotamus)
- E.g Verlorenkloof – Habits (am/pm); and habitat characteristics

Effective or Permissible Carrying Capacity (ECC)

Definition: The maximum number of visitors that a site can sustain, given the management capacity (MC) available.

Formula: ECC = [Infrastructure Capacity x MC] / RCC

Where:

ECC = effective carrying capacity
MC = management capacity based on staff and budget
RCC = real carrying capacity

Assumptions: To determine the ECC, the following assumptions must be clarified:

- MC – defined as the sum of conditions that the water resource management requires if it is to carry out its functions and objectives;
- Measuring MC is not easy, involving many variables, including inter alia policy measures, legislation, infrastructure, facilities, amenities and equipment, staff (both number and competency), funding, available budget, motivation and commitment;
- Limitations in management capacity constitute one of the most serious problems confronting recreational water resource management;
- As the capacity to manage recreational water resources increases, the ECC will increase, yet never be greater than the RCC, even in the most favourable conditions; and
- MC is determined by using the following formula:

MC = Current staff and budget capacity / required staff and budget

6. A CASE STUDY: DETERMINING RECREATIONAL WATER USE CARRYING CAPACITY FOR THE PONGOLAPOORT DAM

Determine PCC

PCC = A x U/a x Rf

Where:

A = 15 000 ha (mean surface area of the dam) – 4 000 ha (area in Swaziland)
= 11 000 ha
U/a = 1 boat/5 ha
Rf = 1 (weekends on average)

Thus: PCC = 11 000 x (1 boat/5 ha) x 1 = 2 200 boats

Determine RCC

RCC = PCC – Cf1 – Cf2 - Cfn and Cf = [M1 / Mt] x 100

<u>Determine Cf</u>

Excessive sunshine (Cfs)

12 hrs = 06:00 – 18:00 Summer Oct – Feb
10:00 – 15:00 sunshine is excessive = 5 excessive sunshine hours per day

Thus: 5 months = 150 days

M1 = 150 days per year x 5 excessive sunshine hours per day
= 750 hours of excessive sunshine per year

Mt = 365 days x 12 hours = 4 380

Then Cfs = excessive sunshine corrective factor
= [M1 x 100] / Mt
= [750 x 100] / 4 380
= 17% corrective factor for sunshine

Wind (Cfw)

12 weeks excessive wind (6 weeks from Feb – Mar; 6 weeks from Aug – Sept)
6 hours per day (pm)

M1 = [12 x 7 windy days] x 6 hours of limiting wind
= 504 hours of wind per year

Mt = Total number of use hours per day x 365 days
= 12 x 365
= 4 380 use hours per year

Then Cfw = excessive wind corrective factor
= [M1 x 100] / Mt
= [504 x 100] / 4 380
= 11.5% corrective factor for wind

Water Quality (Cfwq)

6 months of the year – water quality is ideal for fishing – clear & warm
(Ideal: Aug – Nov; Apr – May)

M1 = 6 months ideal water quality

Mt = Total number of use months
= 12 months

Then Cfwq = water quality corrective factor
= [M1 x 100] / Mt
= [6 x 100] / 12
= 50% corrective factor for water quality

Mud (Cfm)

1 month of the year (Oct – Nov) – excessive mud as result of releases

M1 = 1 month excessive mud

Mt = Total number of use months
= 12 months

Then Cfm = mud corrective factor
= [M1 x 100] / Mt
= [1 x 100] / 12
= 8% corrective factor for mud

Temporary Closure (Cfc)

During the winter months the reserve is temporarily closed for maintenance, for a period of 2 weeks.

M1 = 2 weeks closure

Mt = Total number of use weeks
= 52 weeks

Then Cfc = closure corrective factor
= [M1 x 100] / Mt
= [2 x 100] / 52
= 3.8% corrective factor for temporary closure

Disturbance to Wildlife (Cfwt)

Three target species – water birds, crocodile and hippopotamus. Water birds are sensitive to disturbance during the breeding season, with some birds breeding in reeds on floating nests. Crocodile and Hippopotamus breed in an area of 750 ha.

Cfw = *corrective factor for disturbance of birds*

M1 = 3 months per year

Mt = Total number of months per year
= 12 months

Then Cfw1 = disturbance of birds corrective factor
= [M1 x 100] / Mt
= [3 x 100] / 12
= 25% corrective factor for temporary closure

Cfw2 = *corrective factor for disturbance of crocodile & hippopotamus*

M1 = Breeding area occupied by crocodile & hippopotamus
= 750 ha

Mt = Total number of available area
= 15 000 ha

Then Cfc = closure corrective factor
= [M1 x 100] / Mt

= [750 x 100] / 15 000
= 5% corrective factor for disturbance to crocodile & hippopotamus

Thus Cfwt = total corrective factor for disturbance of wildlife
= 25% + 5%
= 30% corrective factor for disturbance of wildlife

Thus: RCC = PCC – Cfs – Cfw – Cfwq – Cfm – Cfc – Cfwt

RCC = 2200 x [100 - Cfs]/100 x [100 - Cfw]/100 x [100 - Cfwq]/100 x [100 - Cfm]/100 x [100 - Cfc]/100 x [100 - Cfwt]/100

RCC = 2200 x (0.83 x 0.885 x 0.5 x 0.92 x 0.962 x 0.7)
= 2200 x 0.227
= 499

Determine ECC

ECC = [Infrastructure Capacity x MC] / RCC

It takes approximately 20 minutes to launch or retrieve a boat during the day, and there are 3 slipways (1 at Golela; 2 at Poort). There are 3 existing lawful users namely, KZN Wildlife (1 boat allowed); DWAF (1 boat allowed) and 3 adjacent landowners (2 boats allowed each). Currently there are 5 concessions, each with 2 boats allowed. Management function is carried out by a team of 12 staff, however a management team of 18 is required for affective management.

Determine Infrastructure capacity

Infrastructure capacity = [12 hours available per day/20 min] x 3 slipways + Existing lawful Users + Concessionaires
= [720/20] x 3 + [1 + 1 + 6] + 10
= 126

Determine Management capacity as expressed in percentage

MC = Current staff and budget capacity / Required staff and budget capacity x 100
= 12 / 18 x 100
= 66%

And ECC = [Infrastructure Capacity x MC] x 100 / RCC

ECC = [Infrastructure Capacity x MC] x 100/ RCC
= [124 x 0.66] x100 / 499
= 16%

Thus ECC is 16% of the RCC given the current management and infrastructural development, which represents 80 boats allowed on the Pongolapoort Dam currently.

These 80 boats consist of:

10 concession boats, 8 existing lawful user boats and 62 day visitor as well as overnight camping boats. This represents the amount of boats that site management may allow.

7. REFERENCES

Ceballos-Lascurain, H. 1996. Tourism, Ecotourism and Protected Areas: The state of nature-based tourism around the world and guidelines for its development. IUCN, Gland, Switzerland and Cambridge, UK.

Cifuentes Arias, M. 1992. Determinacion de Capacidad de Carga Turistica en Areas Protegidas. CATIE, Turrialba, Costa Rica.